MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
"KHARKIV POLITECHNIC INSTITUTE"

Department **"PHYSICS"**
(name of department that provides the subject teaching)

«**APPROVED BY**»
Head of the Department of Physics _____ O.A. Lyubchenko
(name of department) (signature) (full name)

«_____»_____

SUBJECT STUDY WORKING PROGRAM

PHYSICS
(subject title)

Level of higher education The first (Bachelor)
The first (Bachelor)/the second (Master)

Field of learning 14 Electrical Engineering
(code and title)

Specialty 141 Electricity, electrical engineering and electromechanics
(code and title)

Study program Electrical power engineering
(name of educational program of specialty)

Subject type General training
(general training /professional training; required/optional)

Form of education Full-time
(full-time / part-time / distance)

Kharkiv – 2019

APPROVAL

Subject Study Working Program Physics
(subject title)

Developer:

Head of the Department of Physics
PhD, Professor, _____ O.A.Lyubchenko
(position, academic degree and academic title) (signature) (full name)

Subject Study Working Program has been considered and approved at the meeting of the Department of Physics

Minutes of the Department of Physics №_____ «____»_____

Head of the Department of Physics _____ O.A.Lyubchenko
PhD, Professor (signature) (full name)

COFIRMATION

Code and title of Study Program	Full name of the Study Program Director	Signature
141 Electricity, electrical engineering and electromechanics	Lazurenko O.P.	

Head of the group for specialty assurance

Head of the Department “Electric Power Stations”
PhD, Assistant Professor O.P.Lazurenko

«_____» _____

REAPPROVAL OF THE SUBJECT STUDY WORKING PROGRAM

Date of meeting of the department -developer of Subject Study Working Program	Minutes number	Signature of the Head of department	Study Program Director

OBJECTIVES, CORE COMPETENCES, LEARNING OUTCOMES AND STRUCTURAL-LOGICAL SCHEME OF THE ACADEMIC SUBJECT

Objectives: Formation of students' knowledge of the basics of physics, holistic understanding of the fundamental physical laws underlying the physical theories, scientific outlook and methods of cognition, promote the development of thinking, experimental skills and ability to navigate the flow of scientific and technical information, and the development of the ability to put into practice the knowledge acquired in the field of electrical engineering

Core competences: ЗК10, ЗК15
Learning outcomes: ПРП12
Structural-logical scheme of the sublect

Prerequisite of the subject	This course is prerequisite for:
Higher mathematics	All basic technical and special subjects

SUBJECT DESCRIPTION

Semester	Total amount			Type of classroom studies (hours)			Individual student assignments (CP, CW, CGT, CT, P)*	Current control	Semester control	
	Total number (hours / ECTS credits)	From this		Lectures	Labs	Practices, seminars		Control works (number of tasks)	Pass	Exam
		Class activity (hours)	Self-study (hours)							
1	2	3	4	5	6	7	8	9	10	11
1	150 /5	80	70	32	16	32	CGT		-	Exam
2	150/5	80	70	32	16	32	CGT		-	Exam
3	90/3	48	42	16	16	16	CGT		-	Exam
Total	390/13	208	182	80	48	80				

* CP - Course Project, CW- Course Work, CGT- Calculation and Graphical tasks, CT - Calculation Tasks, P - Paper

The ratio of the number of class hours to the total volume is 53%

STRUCTURE OF THE SUBJECT

№	Types of academic activities (Lectures, Labs, Practices, Self-study)	hours	Semester number (if subject is taught for several semesters). Content module titles. Title of topic and questions of each type of activity. Tasks for Self-study.	Recommended sources (basic, supplementary)
1	2	3	4	5
			1st semester	
			Module 1. Mechanics	
	Lecture #1	2	**Topic 1.1.** Introduction. Mechanical motion. Kinematics of the material point (actual path, displacement vector, speed, velocity, acceleration).	[1, 5-10]
	Practice #1	2	Kinematics of translational motion.	[1, 5-10]
	Lab #1	2	Introductory lesson in a lab**. Recording data. Error analysis**	[1, 5-10]
	Lecture #2	2	**Topic 1.2.** Kinematics of rotational motion. The relationship between rotational and translational parameters	[1, 5-10]
	Practice #2	2	Kinematics rotational motion	[1, 5-10]
	Self-study	10	Lecture material processing. Solving an individual assignment on topic	[1, 5-10]
			Module 2. Dynamics	
	Lecture #3	2	**Topic 2.1.** Dynamics of the material point. Inertial frames of reference. Newton's laws. Force and mass. Gravity and weight. Elastic force. Friction force. Gravity. Universal Law of gravitation Newton's Laws	[1, 5-10]
	Practice #3	2	Newton's Laws.	[1, 5-10]
	Lab #2	2	Determination of the acceleration of gravity.	[1, 5-10]
	Lecture #4	2	**Topic 2.2.** The law of conservation of linear momentum. The center of mass of a mechanical system and the theorem on its motion	[1, 5-10]
	Practice #4	2	The law of conservation of linear momentum.	[1, 5-10]

	Lecture # 5	2	**Topic 2.3** Work, energy, power. Kinetic energy and work. Potential energy. Conservative forces. The law of conservation of energy.	[1, 5-10]
	Practice #5	2	The law of conservation of energy.	[1, 5-10]
	Lab #3	2	Collisions of the balls	[1, 5-10]
	Lecture # 6	2	**Topic 2.4.** Rotational dynamics. Angular momentum. Torque. The law of conservation of angular momentum. The rotation of the body around a fixed axis. The law of conservation of angular momentum.	[1, 5-10]
	Practice #6	2	The law of conservation of angular momentum.	[1, 5-10]
	Lab #4	2	Verification of Newton's 2nd law for rotational motion	[1, 5-10]
	Lecture # 7	2	**Topic 2.5.** Moment of inertia. The 2nd law for rotation - the basic equation of the rotational dynamics. Determination of the momenta of inertia. Steiner's theorem. Kinetic energy of a rotating body.	[1, 5-10]
	Practice #7	2	Rotational dynamics	[1, 5-10]
	Self-study	20	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[1, 5-10]
			Module 3. Oscillation and Waves	
	Lecture # 8	2	**Topic 3.1.** Oscillatory processes. Harmonic oscillations. Pendulums. Addition of oscillations. Free damped oscillations. Forced oscillations. Resonance.	[2, 5-10]
	Practice #8	2	Oscillations	[2, 5-10]
	Lab #5	2	Determination of the logarithmic decrement	[2, 5-10]
	Lecture # 9	2	**Topic 3.2**. Waves. Travelling waves. Characteristics of the wave motion. Types of waves. Description of the wave. Wave equation. Standing waves.	[2, 5-10]
	Practice #9	2	Waves	[2, 5-10]
	Self-study	15	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[2, 5-10]

			Module 4. Electricity	
	Lecture # 10	2	**Topic 4.1.** Electric field in vacuum. Coulomb's Law. Electric field strenght. Gauss's theorem and its application.	[3, 5-10]
	Practice # 10	2	Coulomb's Law and electric field strength.	[3, 5-10]
	Lab #6	2	Calibration of galvanometer and determination of its characteristics.	[3, 5-10]
	Lecture # 11	2	**Topic 4.2.** Circulation of the electric field strength vector. Potential. Potential energy and work of electric field	[3, 5-10]
	Practice #11	2	Potential and electric field work	[3, 5-10]
	Lecture # 12	2	**Topic 4.3.** Electric dipole. Electric field of dipole. The force and torque acting on dipole in electric field.	[3, 5-10]
	Practice #12	2	Motion of the charge particles in electric fields	[3, 5-10]
	Lab # 7	2	Investigation of the useful power and efficiency of the voltage source.	[3, 5-10]
	Self-study	15	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[3, 5-10]
	Lecture # 13	2	**Topic 4.4.** Conductor in electrostatic field. Influence of the substance on the field. Electric field inside and outside the conductor. Power consumption. Capacitors.	[3, 5-10]
	Practice #13	2	Capacitors.	[3, 5-10]
	Lecture # 14	2	**Topic 4.5.** Electric field in dielectric. Polarization of dielectrics. Polarization. Gauss theorem for the field of electric displacement vector. Dielectric permeability.	[3, 5-10]
	Practice #14	2	Electric dipole.	[3, 5-10]
	Lecture # 15	2	**Topic 4.6.** Direct electric current. Ohm's law in integral and differential forms. EMF. Current sources. Kirchhoff's Laws	[3, 5-10]
	Practice #15	2	Electric current	[3, 5-10]
	Lab # 8	2	Kirchhoff's Laws for circuits.	[3, 5-10]

	Lecture # 16	2	**Topic 4.7.** Thermal effect of current. Joule-Lenz law. Classical electronic theory of electrical conductivity of metals. Chemical effect of current. Electric current in electrolytes. Electric current in gases. Magnetic action of the current.	[3, 5-10]
	Practice #16	2	Final lesson.	[3, 5-10]
	Self-study	10	Lecture material processing. Independent study of topics and non-teaching questions.	[3, 5-10]
			2nd semester	
			Module 5. Magnetism	
	Lecture #17	2	**Topic 5.1.** Magnetic field in vacuum. Biot-Savart Law. Magnetic field of direct and circular currents. Magnetic field of moving charge.	[3, 5-10]
	Practice #17	2	Biot-Savart Law	[3, 5-10]
	Lecture #18	2	**Topic 5.2.** Basic laws of the magnetic field. Gauss's theorem for the field of vector B. Theorem on the circulation of vector B and its application.	[3, 5-10]
	Practice #18	2	Basic laws of the magnetic field	
	Lab #9	2	Measurement of the earth's magnetic field by means of tangent galvanometer.	[3, 5-10]
	Lecture #19	2	**Topic 5.3.** Ampere's force. Force and torque on current circuit in magnetic field. Work done for loop motion in magnetic field.	[3, 5-10]
	Practice #19	2	Ampere's force. Mechanical and magnetic moments	[3, 5-10]
	Lecture #20	2	**Topic 5.4.** Lorentz force. The motion of charged particles in magnetic field.	[3, 5-10]
	Practice # 20	2	Lorentz force	
	Lab #10	2	Lorentz force	[3, 5-10]
	Lecture #21	2	**Topic 5.5.** Magnetic field in substance. Magnetization. Vector H and the theorem on its circulation. Dia- and paramagnets.	[3, 5-10]
	Practice #21	2	Lorentz force. The motion of charged particles in magnetic field.	[3, 5-10]
	Lecture #22	2	**Topic 5.6.** Ferromagnetism. Basic magnetization curve. Magnetic hysteresis. Curie temperature. The physical nature of ferromagnetism.	[3, 5-10]
	Practice #22		Motion of the particles in magnetic fields	

	Lab #11	2	Ampere's force determination	[3, 5-10]
	Lecture #23	2	**Topic 5.7.** Electromagnetic induction. Faraday's Law. Lenz's Law. The nature of electromagnetic induction. Eddy currents. Self-induction and mutual induction. Inductance. Transformer. Energy of magnetic field.	[3, 5-10]
	Practice #23	2	Electromagnetic induction	[3, 5-10]
	Lecture #24	2	**Topic 5.8** Self-induction and mutual induction. Inductance. Transformer. Energy of magnetic field.	[3, 5-10]
	Practice #24		Self-induction and mutual induction.	
	Lab #12	2	Determination of the magnetic dip angle by means of the field structure and ballistic galvanometer	[3, 5-10]
	Self-study	20	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[3, 5-10]
	Lecture #25	2	**Topic 5.9.** Maxwell's equations and electromagnetic waves. Poynting vector. Electromagnetic spectrum	[3, 5-10]
	Practice #25	2	Self-induction and mutual induction. Transformer	[3, 5-10]
	Lecture #26	2	**Topic 5.10.** Alternating current circuits. Electromagnetic oscillations. AC circuits with resistors and capacitor	[3, 5-10]
	Practice #26		Alternating current circuits. Electromagnetic oscillations.	
	Lab #13	2	Double-wire line	[3, 5-10]
	Lecture #27	2	**5.11**. RLC circuits. Damped oscillations. Driven oscillations in RLC circuit. Resonance	[3, 5-10]
	Practice #27	2	Oscillations in LC and RLC circuits.	[3, 5-10]
	Self-study	10	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[3, 5-10]
			Module 6. Wave optics	
	Lecture #28	2	**Topic 6.1.** Geometric optics. The development of ideas about the nature of light. Laws of propagation, reflection and refraction of light. Interference of light. Coherence. Constructive and destructive interference.	[4-10]

	Practice #28		Interference. . Constructive and destructive interference.	
	Lab #14	2	Determination of curvature radius of lens and light wavelength by means of Newton's rings	[4-10]
	Lecture #29	2	**Topic 6.2.** Young's double-slit experiment. Interference in thin films. Newton's rings. Applications of interference.	[4-10]
	Practice #29	2	Interference in thin films	[4-10]
	Lecture #30	2	**Topic 6.3.** Diffraction. Huygens-Fresnel principle. Fresnel zones. Fresnel diffraction. Fraunhofer diffraction. Diffraction grating. Diffraction on spatial structures. Holography. Polarization of light. Natural and polarized light. Interaction of electromagnetic waves with matter. Dispersion	[4-10]
	Practice #30		Diffraction.	
	Lab #15	2	Determination of wavelength by means of diffraction grating and double-slit light source	[4-10]
	Self-study	10	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[4-10]
			Module 7. Quantum optics	
	Lecture #31	2	**Topic 7.1** Elements of the special theory of relativity. Postulates STO. Lorentz transformations and consequences of them. Relativistic dynamics. Thermal radiation and its characteristics. Kirchhoff's Law. Stefan-Boltzmann Law. Rayleigh-Jeans Formula. Quantum hypothesis. Planck formula. Practical applications (optical pyrometry)	[4-10]
	Practice #31	2	Special theory of relativity. Thermal radiation.	[4-10]
	Lecture #32	2	**Topic 7.2.** Photons. X-rays. Photoelectric effect. Einstein equation. Threshold wavelength. work function. Compton effect. Wave-particle duality.	[4-10]
	Practice #32		Photons. X-rays. Photoelectric effect. Einstein equation.	
	Lab #16	2	Determination of Stephan-Boltzmann constant	[4-10]
	Self-study	16	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[4-10]

			3rd semester	
			Module 8. Physics of atom and nucleus	
	Lecture #33	2	**Topic 8.1.** Elements of quantum mechanics. Wave properties of microparticles. De Broglie waves. Wave function. Heisenberg uncertainty relationship. Schrödinger equation. Quantization of physical quantities.	[4-10]
	Practice #33	2	Material waves. Heisenberg uncertainty relationship.	[4-10]
	Lab #17	2	Determination of de Broglie wavelength using electron diffraction pattern.	[4-10]
	Lecture #34	2	**Topic 8.2.** Hydrogen-like system in quantum mechanics. The mechanical and magnetic moments of the electron and atom. Spin of electron Pauli principle. The periodic system of D.I. Mendeleev. X-ray spectra. Mosley's Law.	[4-10]
	Practice #34	2	Hydrogen atom. Mosley's Law.	[4-10]
	Lab #18	2	Hydrogen spectrum.	[4-10]
	Lecture #35	2	Physics of the atomic nucleus. Radioactivity. Nuclear reactions.	[4-10]
	Practice #35	2	X-ray spectra. Radioactivity	[4-10]
	Lab #19	2	The study of fluctuations in the natural background radiation	[4-10]
	Self-study	25	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[4-10]
			Module 9. Molecular physics and thermodynamics. Physical kinetics	
	Lecture #36	2	**Topic 9.1** Molecular-kinetic theory. The relation between heat capacity and the number of degrees of freedom of gas molecules. Maxwell distribution of ideal gas molecules. Experimental justification of the Maxwell distribution. Boltzmann distribution and barometric formula	[6-10]
	Practice #36	2	Molecular-kinetic theory	[6-10]
	Lab #20	2	Determination of the mean free path and effective diameter of air molecules	[6-10]
	Lecture #37	2	**Topic 9.2**. Thermodynamic equilibrium and temperature. Reversible and irreversible processes. Laws of thermodynamics. Heat capacity. Mayer's equation. Isochoric, isobaric, isothermal, adiabatic processes in ideal gases. Converting heat to mechanical work. Carnot cycle	[6-10]

			and its efficiency. Entropy.	
	Practice #37	2	Thermodynamics	[6-10]
	Lab #21	2	Determination of the ratio of the molar heat capacities for air	[6-10]
	Lecture #38	2	**Topic 9.3.** Elements of physical kinetics. Transport phenomena. Diffusion, thermal conductivity, internal friction. Empirical transport equations. Relaxation to an equilibrium state.	[6-10]
	Practice #38	2	Physical kinetics	[6-10]
	Lab #22		Measuring the coefficient of internal friction by stocks' method	[6-10]
	Self-study	25	Lecture material processing. Independent study of topics and non-teaching questions. Solving an individual assignment on topic	[6-10]
			Module 10. Elements of solid state physics	
	Lecture #39	2	**Topic 10.1.** The concept of quantum statistics of Fermi - Dirac and Bose - Einstein. Structure of solids. Distribution of conduction electrons in metals by energy. Fermi energy. Energy zones in crystals. The distribution of electrons in energy zones. Valence band and conduction band. Metals, dielectrics and semiconductors.	[6-10]
	Practice #39	2	Semiconductors	[6-10]
	Lab #23	2	Determination of the band gap of semiconductor	[6-10]
	Lecture #40	2	**Topic 10.2.** Semiconductors. Intrinsic and extrinsic semiconductors. Conduction in intrinsic and extrinsic (p- and n-type) semiconductors. p–n - transition and current-voltage characteristics. Transistors.	[6-10]
	Practice #40	2	Final lesson	[6-10]
	Lab #24	2	Determination of the lifetime of nonequilibrium charge carriers in semiconductor	[6-10]
	Self-study	22	Lecture material processing. Independent study of topics and non-teaching questions.	[6-10]
	Total (hours)	**390**	**192(class) / 198 (Self-study)**	

Notes

1. The semester number indicates if the subject is taught for several semesters.
2. In the Total (hours) indicator, the number of hours will differ from the total number of class hours by the number of Self-study hours
3. The column 5 indicates the number in accordance with **RECOMMENDED READING**

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SELF-STUDY

№	Self-study type	%
1	Lecture material processing	30
2	Self-study of topics and non-teaching questions	20
3	Solving an individual assignment on topic	50
	Total	100

INDIVIDUAL TASKS

Individual assignments

	№	Title of individual task and/or its sections	Terms of implementation (week number)
1st semester	1	Kinematics	3
	2	Dynamics	7
	3	Oscillations and waves	10
	4	Electricity	15
2nd semester	5	Magnetism	6
	6	Electromagnetic oscillations	8
	7	Wave optics	10
	8	Quantum optics	15
3rd semester	9	Modern physics	6
	10	Molecular Physics and Thermodynamics	9

TEACHING METHODS

During the physics teaching, the following **teaching methods** are used: verbal (lectures), visual (illustrations and demonstrations using experimental equipment, multimedia, popular science films, etc.), and practical (laboratory experiments and practical work).

The purpose of the lecture is to form students' basic knowledge of physicsLecture is the main type of training activity designed to assimilate theoretical material and introduce students to a certain system of scientific knowledge and methodology of science.

Labs are the forms of study when the student under the guidance of the teacher conducts in-situ or simulation experiments or experiments with the purpose of practical confirmation of certain theoretical provisions of the discipline, acquires practical skills in working with laboratory equipment, equipment, computing technique research in a specific subject area. Labs are conducted in specially equipped laboratories using equipment adapted to the conditions of the educational process.

Practice is a form of training in which the teacher organizes a detailed examination of certain theoretical ideas of the subject and forms the knowledge and skills of their practical application.

In addition, talented student youth have the opportunity to carry out research work outside the classroom. The results of such works are heard at the Regional Scientific Student Conference, which is held annually at the department.

CONTROL METHODS

Current control is carried out during practices, laboratory classes and is aimed at checking the level of student's readiness to perform specific work, and in the form of defense of the laboratory work after conducting the laboratory classes. Current control is carried out by different methods: oral (speaking in front of the class), written (control tasks, control work, etc.), tests, assignments (individual tasks, calculation and graphical tasks, abstracts, etc.).

Modular control is an indicator of the quality of students' study of certain sections of Physics. Modular control is conducted in the form of colloquium or written test. Modular control papers may include the theoretical questions and problems.

Final control involves determining the level of students' learning at the end of the semester or after completing the study of the subject. It takes the form of an exam or pass.

The student is considered to be admitted to the semester exam in Physics after completion of all tasks of practical and laboratory classes, calculation and graphical tasks stipulated by the subject program.

DISTRIBUTION OF THE CREDIT POINTS RECEIVED BY STUDENTS AND KNOWLEDGE AND SKILLS ASSESSMENT SCALE (NATIONAL AND ECTS)

Table 1. Distribution of the credit points received by a student for exam

Lecture material	Labs	CGT	Individual tasks	Exam	Sum
15	10	15	50	10	100

Table 2. Knowledge and skills assessment Scale: National and ECTS

Amount of points for all types of learning activities	ECTS grade	National Scale grade
90-100	A	excellent
82-89	B	good
75-81	C	

64-74	D	satisfactory
60-63	E	
35-59	FX	unsatisfactory with the possibility of re-examination
0-34	F	unsatisfactory with compulsory re-study of subject

LEARNING AND TEACHING MATERIALS

1. Working curriculum of Physics.
2. List of recommended reading (basic and additional) on the lecture topics.
3. Schedule of lectures, labs, and practice.
4. Lecture notes, Problem solving guides, and Laboratory Manual
5. Lecture demonstrations.
6. Test tasks for checking students' preparation for labs.
7. Assignments for individual solutions
8. A set of control tasks prepared by the teachers of department.
9. Posters for lectures, labs and practical classes.
10. Criteria for assessing students' knowledge of the subject.
11. A set of papers for modular control.
12. A set of the papers for exams.
13. Other materials.

RECOMMENDED READING

Basic sources

10	Lyubchenko O. A. Mechanics : [study guide] Механіка : навч.-метод. посібник / О. А. Lyubchenko. – Kharkiv : NTU "KhPI", 2016. – 324 p. – Engl. lang.
2	Lyubchenko O. A. Mechanics. Oscillations and waves : Конспект лекций по курсу "Физика" на англ. яз. / Е. А. Любченко, А. Ю. Гребенник ; Нац. техн. ун-т "Харьк. политехн. ин-т". - Х. : НТУ "ХПИ", 2006. - 51 р.
3	Lyubchenko O. A. Electricity and Magnetism: Конспект лекций по курсу "Физика" на англ. яз.; - Х. : НТУ "ХПИ", 2006. - 71 с.
4	Lyubchenko O. A. Optics. Atomic and Nuclear Physics: Конспект лекций по курсу "Физика" на англ. яз. НТУ "ХПИ", 2006. - 122 с.
5	Любченко Е.А. Методические указания к выполнению лабораторных работ по курсу "Физика" Physics: Laboratory manual, Харьков, НТУ «ХПИ». 2006. - 64 с.

Supplementary sources

6	D.C.Giancoli. Physics for scientists and engineers with modern Physics. 4th ed., Pearson Education, Inc., USA, 2009.
7	N.J.Giordano. College Physics. Reasoning and Relationships. 2 ed., V1 and 2, Brooks/Cole, Cengage Learning, USA, 2010

8	Physics. Principles and Problems. Glencoe Science Program. Interactive Students Edition., 2005 http://physicspp.com
9	J. Walker. Fundamentals of physics /J.Walker, D. Halliday, R. Resnick - 10th extended ed., USA, 2014
10	R.A.Serway, C.Vuille, J.S.Faughn. College Physics. Brooks/Cole, Cengage Learning, USA, 2009

INFORMATION RESOURCES FROM INTERNET

1. http://web.kpi.kharkov.ua/tef/Laboratornyj-praktikum/cp/
2. http://cde.kpi.kharkov.ua/cdes/LMNP.htm
3. http://dl.khpi.edu.ua/